

EARLY COMPREHENSION OF SCIENTIFIC CONCEPTS*

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The recent surge of interest in presenting scientific concepts to public school pupils before their high school years (Sci. Educ., 1960) increases the prospect of assuring an adequate supply of scientists for the future. It also anticipates the equally important need for a scientifically-oriented citizenry to support scientific progress in depth. In addition to these manifest advantages, the success achieved thus far in extending the teaching of basic scientific ideas to the early secondary and elementary levels has other implications, and it is these which stimulate the writing of this paper.

The journal, *Science Education*, has recently devoted an entire issue (March, 1960) to reporting progress in introducing ideas, hitherto reserved for much later periods in academic life, to selected and unselected groups of elementary and secondary school pupils. Among 16 papers on the subject in this issue, the majority deals with elementary education. Experiments of a similar nature are reported in other journals from the University of Illinois, the University of Indiana, Stanford University, the Massachusetts Institute of Technology, and a host of other institutions. At Berkeley, California, the municipal school authorities have created a special organization to study the success of a pilot program for elementary school children which has been undertaken with assistance from specialists from nearby universities. The possibilities presented by these practices for reorganizing school curricula and in changing certification requirements for teachers are immediately apparent. It is already evident that traditional notions about the receptivity of the young child must be revised (Garone, 1960). Suggested early introduction of nonscience concepts has also been made, with regard to philosophy, particularly.

The persistence of maxims referring to the importance of the early years, such as Jonathan Swift's, "Give me a boy until he is six, and you may do with him what you will," and, "As the twig is bent, the tree's inclined," is well known. They lend weight to the recognition of a fundamental principle which is clearly involved, but has lacked adequate, scientific support. What support has been forthcoming has been delayed by seemingly inordinate attention paid to maturation, critical stages, "late blooming," latency and other phenomena. The discovery (or rediscovery), that it does not appear to be necessary to delay the teaching of complex ideas until puberty or beyond, on the assumption that young minds are not "ready," impels a more penetrating examination of the educational sequence as a whole. To stimulate such an examination the following hypothesis is offered, with the realization that if results in accord with what has already been discovered further support it, a radical revision of our outlook upon educational practices is inevitable.

THE IMPORTANCE OF SUCCESSIVE EVENTS

If the life of an individual were represented along the abscissa of a graph, beginning with conception and ending with natural death, and on the ordinate were arranged arbitrary values for "the relative importance of events during life," based upon known but disconnected events from conception to death, a sloping line would be formed, high at the start and gradually diminishing in height until death (fig. 1). The precise slope of the line is open to question, but the diminishing

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magnitude of successive events in determining ultimate destiny is much less so. Evidence supporting this generality can be found in several fields of study:

(a) *Genetics and embryology*.—Conception, it goes without saying, is the occurrence which has the greatest effect upon events to follow. Some consequences of conception are incontestably paramount, such as the determination of sex, while others are recognizably deterministic within narrow limits (somatotype), and still others have wider limits of expression (temperament arising from somatotype). It is my contention that the underlying uniformity of events which are genetically determined has been obscured by over-attention to the extremes of variation. However, the extremes themselves can be used, if desired,

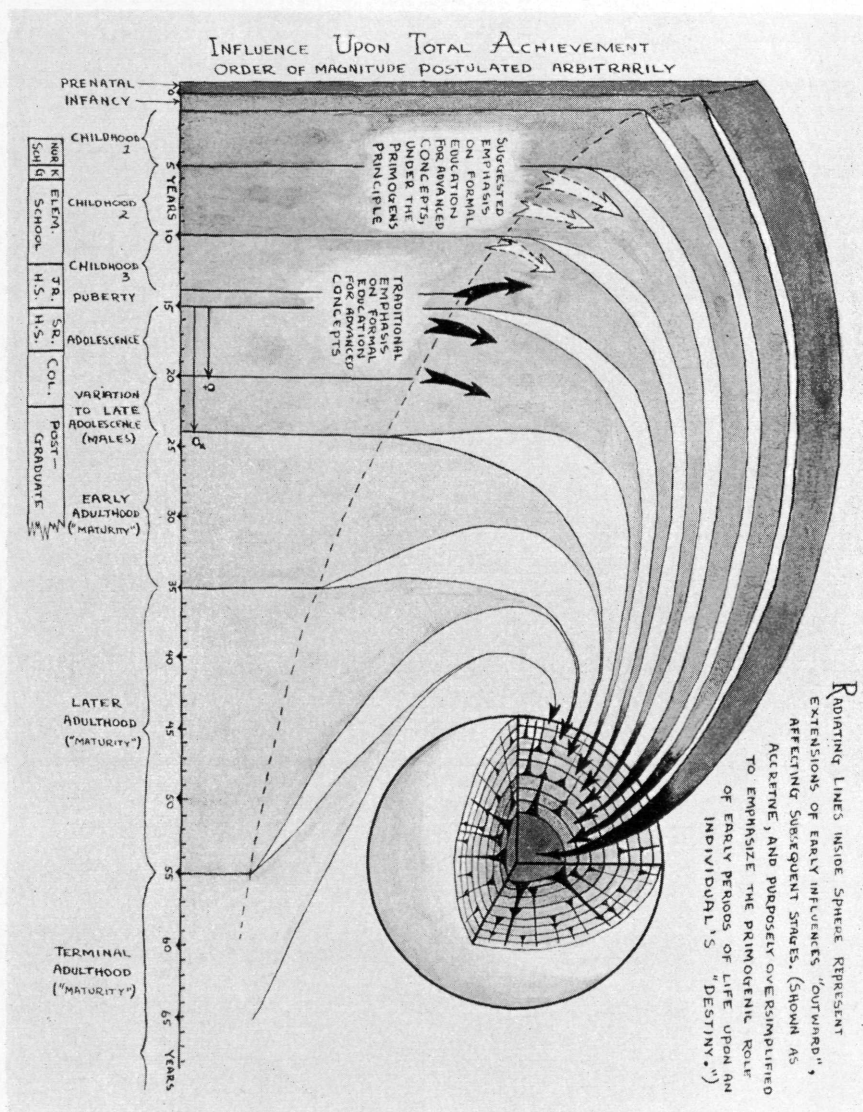


FIGURE 1. Diagram of the hypothetical effect of successive periods of life upon total accomplishments.

to support the thesis that determinism must be exceedingly high, and variations which have beclouded the issue are the result of extenuating circumstances that have preoccupied attention of some educators to the detriment of practical application of the core idea.

Following conception, the occasional but remarkable occurrence of monozygotic twinning lends support to the hypothesis that early events are the most important—what event, other than conception itself, could have a greater influence upon the development of an individual, than that of becoming two? Subsequent events are likewise influential; spina bifida, mongolian idiocy, and blebs leading to the condition known as lobster claw, point to the disastrous effects of early malfunctioning in utero (Stern, 1949).

L. W. Sontag and his co-workers at the Fels Institute have found that if the pregnant mother experiences severe emotional stresses during late pregnancy, her child is likely to be irritable, hyperactive, demanding of more frequent feedings, and “to all intents and purposes a neurotic infant when he is born” (Sontag and Richards, 1938). When it is realized that at eight weeks of age, the fetus (only an inch long) has developed so that reflexive movements can be elicited by tactile stimulation with a bristle, the depth of physiological affects later in fetal life seems much less surprising. These and other examples too numerous to mention emphasize the magnitude of early events in determining the ultimate product.

(b) *Parturition*.—“Normal” delivery covers wide differences between no difficulty and considerable difficulty. Using extremes to illuminate the hypothesis of a descending order of sequential events, it is evident that severe trauma with lasting effects can result from exceptionally difficult parturition, presumably due to compression of the fetus in passing through the birth canal, as well as anoxia producing a degree of damage to sensitive nervous tissue. Because measurement of the extent of damage is almost impossible, the effect of moderately difficult delivery upon the child must be regarded as an unknown but suspect quantity for the present. The extreme viewpoint of Rank (1952) is not adopted by most psychologists, but there is no denial that some effects last for a greater or lesser time. The critical question is the extent to which the nervous system has developed, a factor which itself may vary with inheritance. Many students of the subject attach no little importance to birth trauma.

The presumed degree of insecurity or anxiety arising from birth trauma would appear to have little or no connection with an individual’s orientation toward science, yet the possibility that overt adult behavior related to hidden causes is a factor in facilitating the formation of “right” assumptions should not be ignored altogether. Severe preoccupation with anxiety, however caused, is bound to be an impedence to progress. On the other hand, when all that can be learned is known, it may be concluded that anxiety of a mild sort acts as a prod to discovering cause-and-effect relationships, and therefore anxiety can be a beneficial driving force of no small moment in fashioning an individual’s future.

(c) *Studies of infancy and childhood*.—While the former belief that a child enters the world with a “clean slate” of behavior patterns has almost vanished, there is no positive and clear-cut means of measuring the effects of events in early infancy; only the vaguest outlines of responsive behavior (attitudes?) are presumed to be laid down. At the earliest time cause-and-effect relationships can be dealt with quantitatively, the profundity of early situations of certain types seems clear enough. The state of the mother’s own orientation toward life appears to be clearly communicated to the offspring (Rank, 1952; Rank, B., 1950) (if the mother is poorly oriented, so are the offspring), and basic assumptions acquired by the individual under extreme deprivation in infancy suggests a continuum reaching into the “normal” acquisition of assumptions (Beres et al., 1950); that is to say, the “abnormal” testifies to the existence of effects in the “normal” by extrapolation. How valid extrapolation may be is again open to question. To disregard entirely what extrapolation may offer is to neglect possibilities of prime

importance. In other words, the circumstantial evidence that deeply-felt, traumatic experience is instrumental in developing an individualized, neurotic outlook upon the world can, as a working hypothesis, be arbitrarily inferred to apply with no less force to formal education and an individualized, *normal* outlook upon the world. The *early* educational experiences of children, by this reasoning, are the most influential ones in the academic sequence, and *if this be true the entire educational program deserves reorientation.*

That this principle transcends maturation is a conclusion reached through the same process of reasoning; indeed, the idea of maturation itself strengthens the argument that greater attention than ever should be directed toward perfecting the conditions of early education. As a postulate, the elementary school and secondary school teachers should be not *less* well educated than those in the higher levels, but actually *better* prepared, for their influence probably has a deeper and longer lasting effect.

(d) *Psychiatry*.—It is well known that psychiatrists encourage their patients to delve into the distant past in order to come to grips with all-but-forgotten experiences. Held up to the light of adult perspective, these searing, traumatic events, having had so deep an effect upon the patient as to create intolerable tensions, can then be comprehended by them, with successful adjustment in some cases. When hypnosis is resorted to, a considerable degree of success attends the technique of having the subject "regress" into childhood. The depth and history of troublesome basic assumptions are thus revealed, and the way is open for efforts to treat the patient intelligently.

(e) *Criminology*.—It is again the exceptional and unusual which enlighten us about the general principle, when one observes the effects, for example, of "broken homes" or dissention within the home, upon the course of action followed by children coming from such homes. That social responsibility is undergoing critical development in childhood and adolescence is further indicated by the information that among all male youths classed as delinquents in the United States, only five percent have been Boy Scouts (Hoover, 1959). The desirability of constructive youth organizations—one is tempted to say, the need for compulsory membership in such organizations—is apparent. Behavior patterns at this time do not seem to override early experience so much as they fall into line with the principle here offered.

THE "PRIMOGENS" PRINCIPLE

Drawing upon exceptional circumstances, such as those described briefly above, there appears to be a thread of continuity perceivable. While it has been axiomatic ("The boy is father to the man") that a cause-and-effect relationship can be traced backward to childhood and infancy from adolescent and adult achievements, both "good" and "bad," there has not appeared to be a full realization of what this implies educationally. It is for this reason that the current interest in presenting scientific concepts earlier in the school sequence than tradition has dictated comes as something of a surprise.

What has been lacking is a concise, verbal expression of this principle. Lack of such an expression has impeded the focussing of attention upon the earliest years of life by all but a small group of specialists who see their importance with fair clarity. The term, "primogens," meaning "early beginning," is therefore suggested as a word useful in calling attention to the importance of early events. The primogens principle may then be defined as a statement of the general relationship of sequential events during life from which it can be postulated that each successive period of life has less and less influence upon the ultimate destiny of the individual.

Exceptions may leap to mind, such as blindness occurring in middle life and altering the individual's destiny profoundly. But closer examination of such an unfortunate accident may reveal that whatever early adjustments were or

were not made prior to that time will constitute the degree to which the person successfully copes with the event (Montagu, 1955). Thus what appear to be exceptions may actually cast further light upon the extensiveness of this principle. If we can reorient our thinking to regard maturation and other critical periods in life as ripples along the descending stream of influential events in life, it is likely that the proper perspective will ensue.

APPLICATION OF THE PRINCIPLE

Early comprehension of scientific concepts becomes less of a striking discovery in education, in the light of the primogens principle, and more of a natural exploitation of the potential of individuals.

Following the primogens principle to its conclusion, we can appreciate the tremendous importance of having excellent teachers in the *earliest* stages of education. Everyone of us can probably trace our keen interest in our present endeavors to parents or teachers influencing us very early to cherish curiosity, to love accuracy, and to extend our knowledge of the world about us. If this concept is soundly based, the kindergarten and elementary school become the focus of far greater attention than they have been in the past. Rather than relegating kindergarten and elementary school teachers to a relatively minor role, therefore, teaching in the early levels should confer upon teachers the handsomest rewards of pay and prestige! And the satisfactions springing from having a greater assurance of "academic immortality" will be rewards themselves.

The traditional view—that the best teachers are to be reserved for the higher levels—must be softened at least to the extent that those having proficiency in science and arts, with full cogency of their importance in the academic sequence, and convinced of the validity of the primogens principle, are lured into the *lower* levels of education. Teachers in the lower grades should be well versed in psychology (beyond a single, introductory course), and should themselves be lively, dynamic persons, fully receptive to advanced developments in their field. They should be capable of encouraging curiosity, exploring avenues suggested by pupils' contributions to an "I wonder" box (Bohnhorst and Hosford, 1960), for example, and creating attitudes with the greatest "primogenic" effect. In short, they should not be trained to teach subjects, only, but to teach human beings.

Ultimately, with so propitious a start, able pupils as well as the less gifted would reach, at a much earlier age, that enviable state of education, *self-education*, that is so conspicuous by its absence among a large proportion of our college students today (Pettit, 1960).

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